Title: "SYSTEM FOR ESTIMATING ATTITUDE OF LEG TYPE MOVING ROBOT ITSELF"
First Named Inventor: Toru Takenaka
National Stage of PCT/JP03/05447
Customer No. 40854; Docket No. SAT-15711

FIG. 1

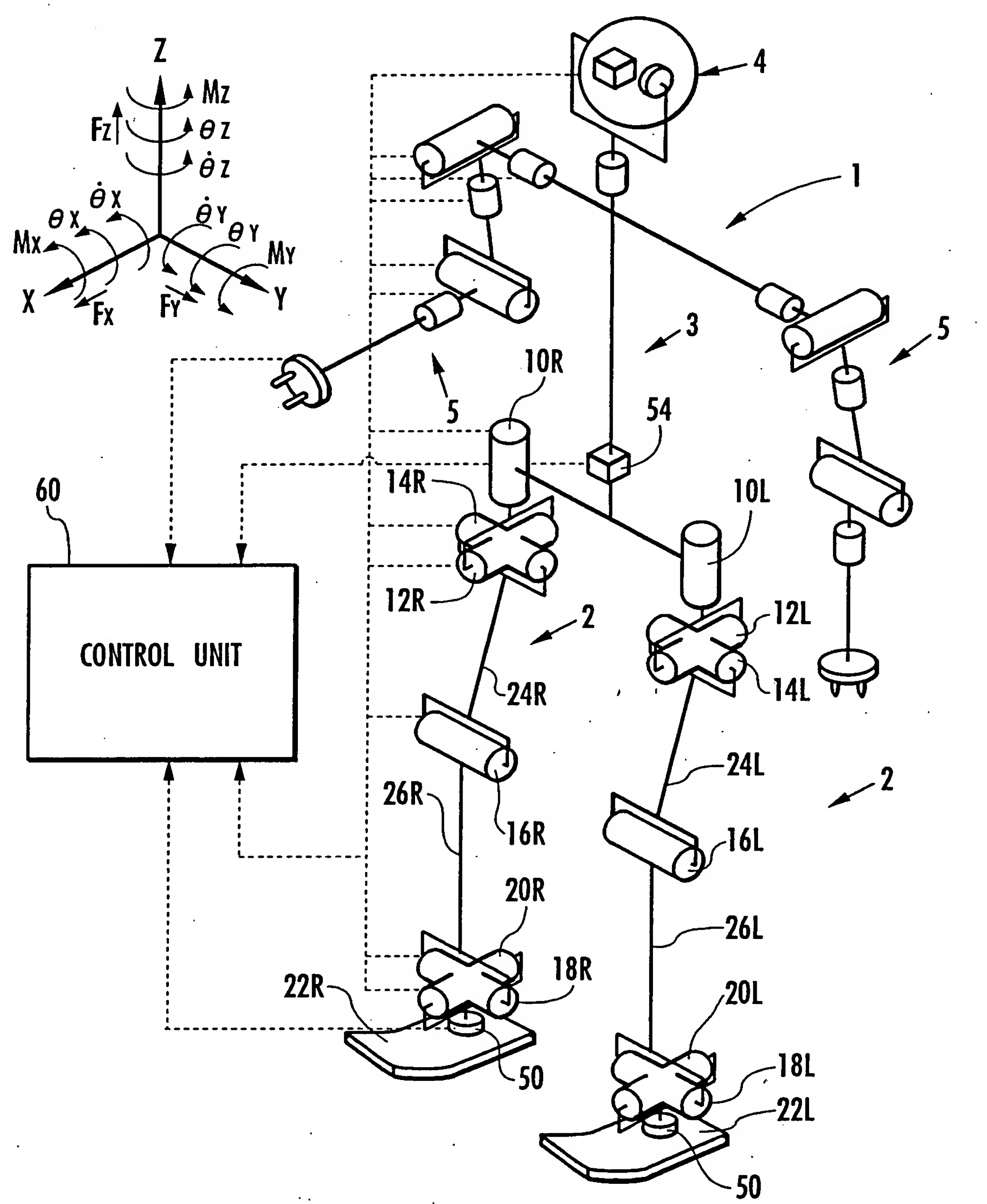

FIG. 2

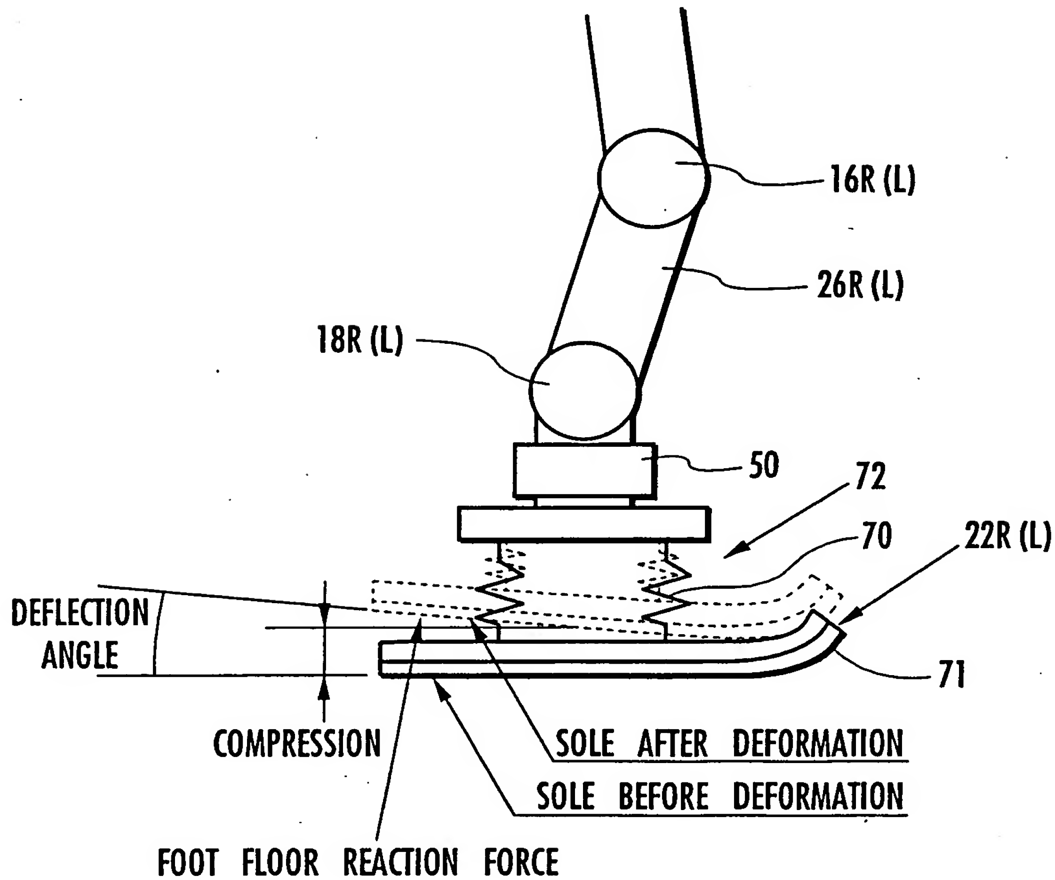
16R (L)
26R (L)
18R (L)
50
72
70
22R (L)
DEFLECTION ANGLE
71
COMPRESSION
SOLE AFTER DEFORMATION
SOLE BEFORE DEFORMATION
FOOT FLOOR REACTION FORCE

FIG. 3

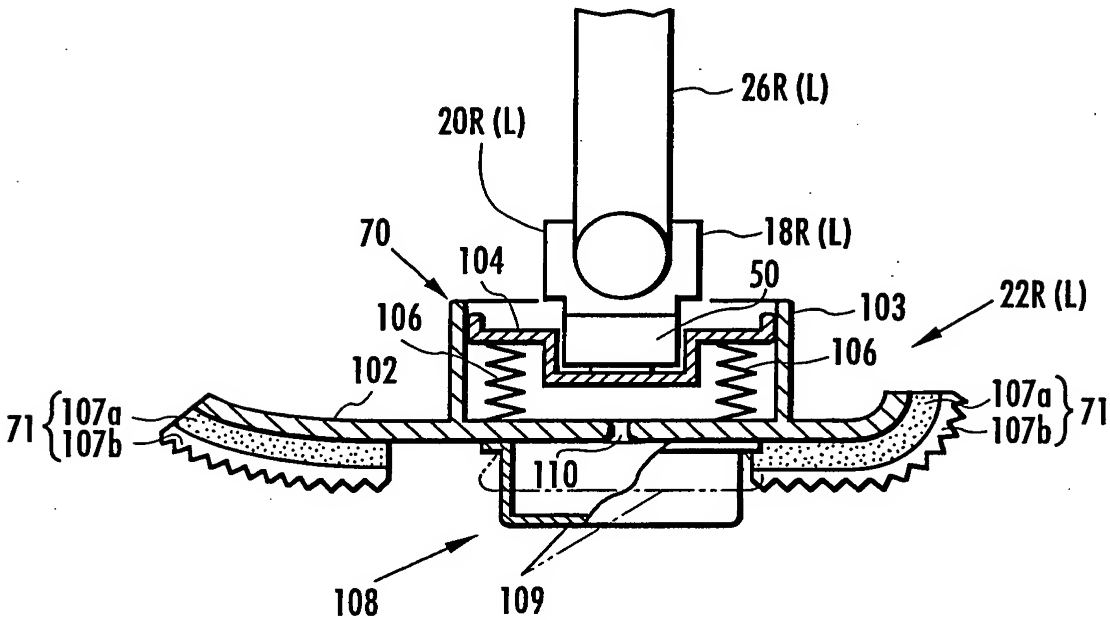
26R (L)
20R (L)
18R (L)
70
104
50
103
22R (L)
106
106
102
71
107a
107b
107a
107b
71
110
108
109

FIG. 4

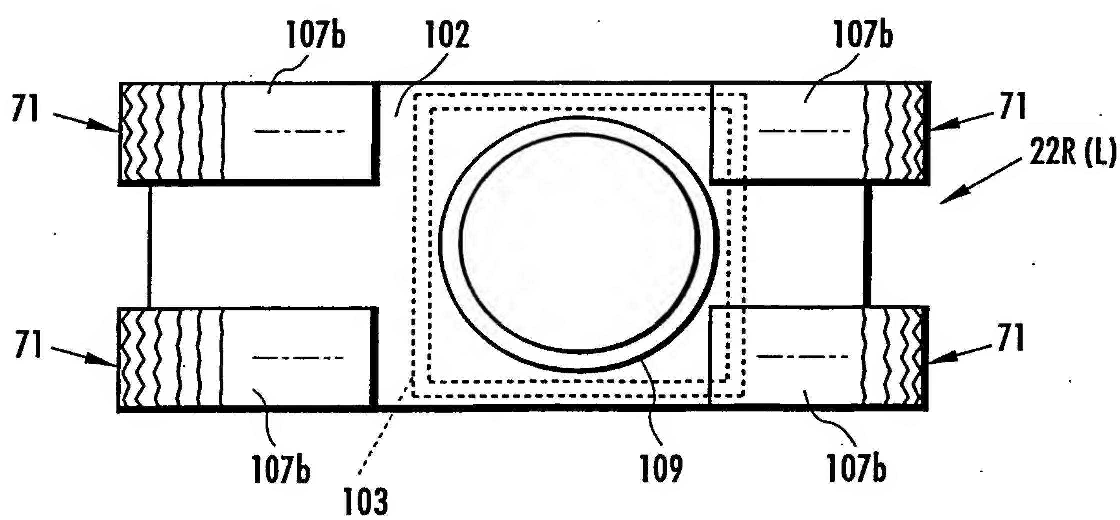
107b
102
107b
71
71
22R (L)
71
71
107b
103
109
107b

FIG. 5

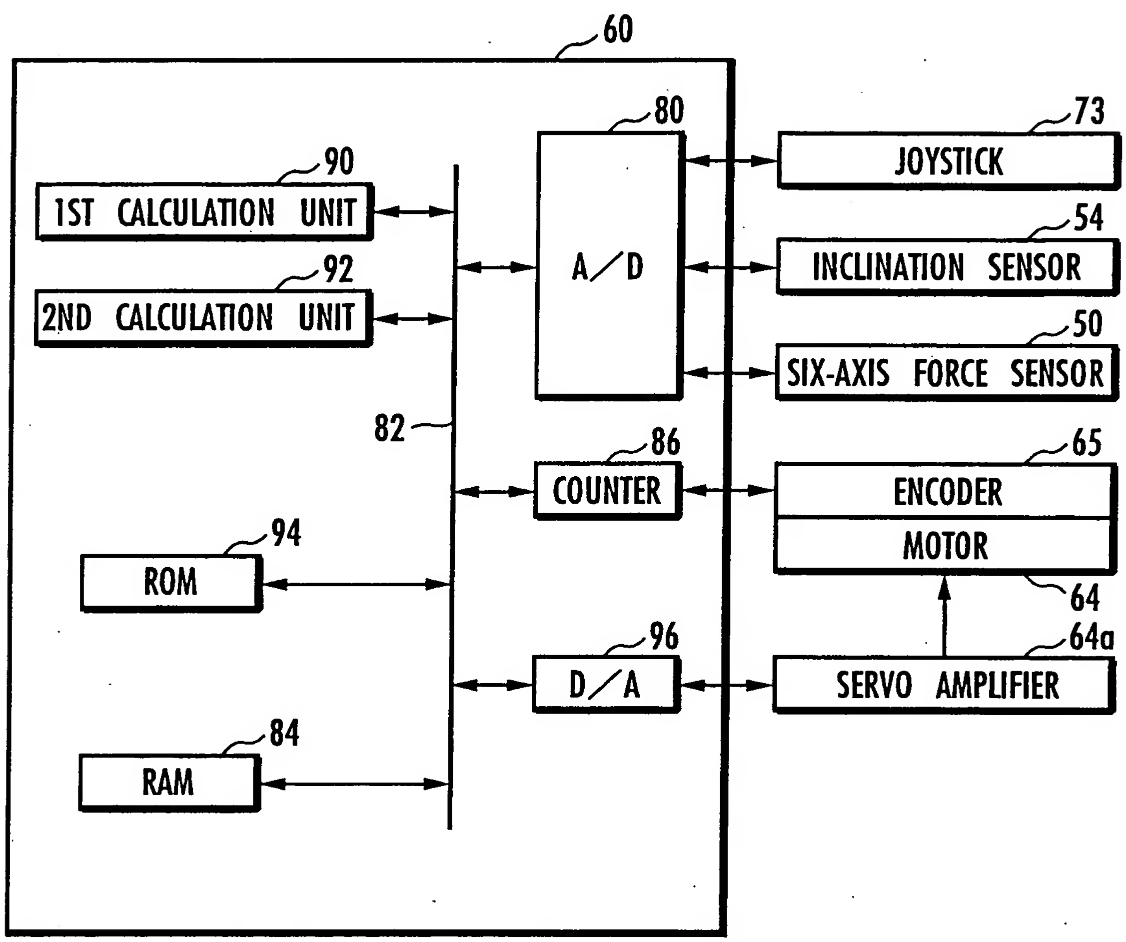
60
80
A/D
73
JOYSTICK
54
INCLINATION SENSOR
50
SIX-AXIS FORCE SENSOR
90
1ST CALCULATION UNIT
92
2ND CALCULATION UNIT
82
86
COUNTER
65
ENCODER
MOTOR
64
94
ROM
96
D/A
64a
SERVO AMPLIFIER
84
RAM

FIG.6

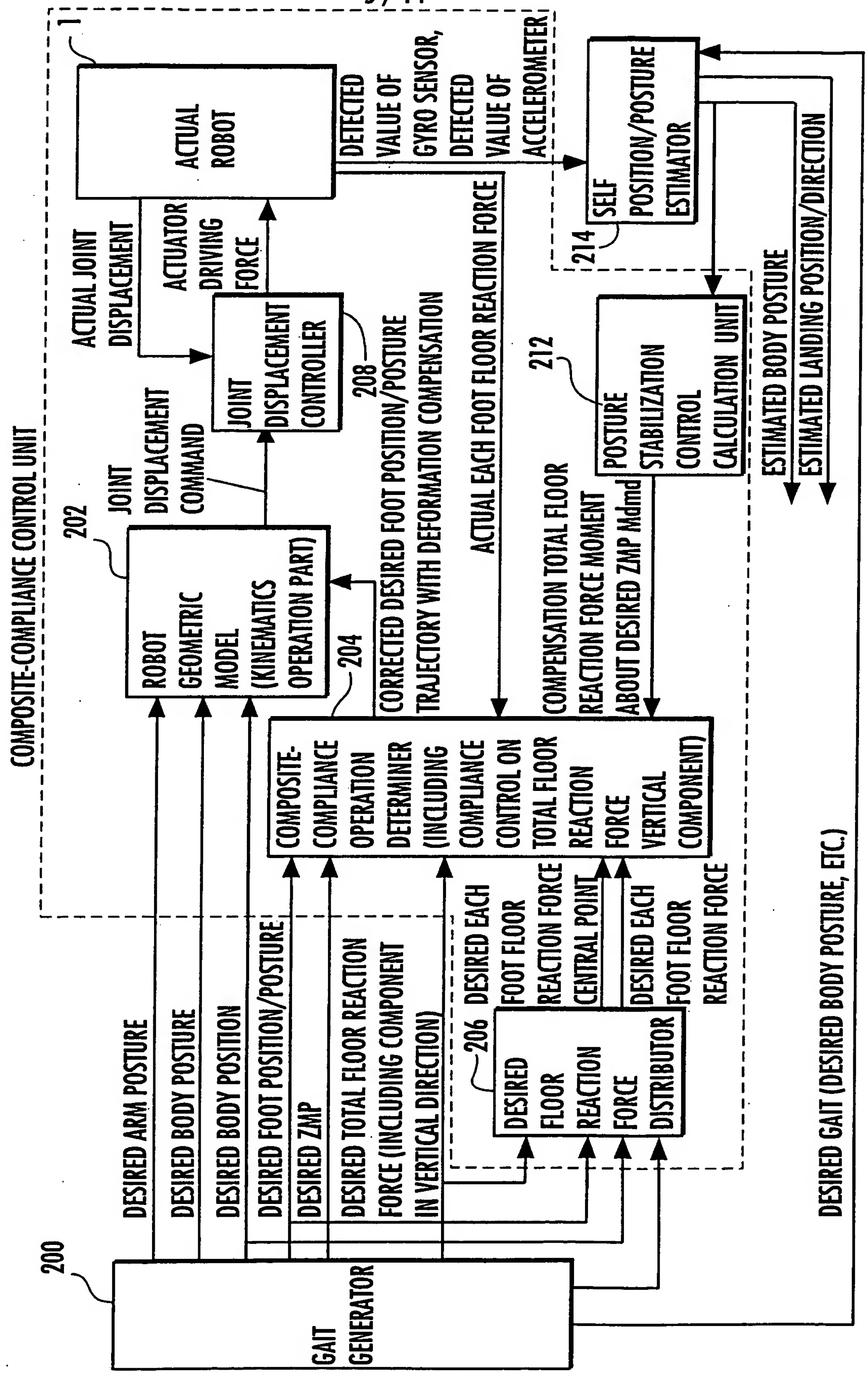
COMPOSITE-COMPLIANCE CONTROL UNIT
1
ACTUAL ROBOT
DETECTED VALUE OF GYRO SENSOR, DETECTED VALUE OF ACCELEROMETER
ACTUAL JOINT DISPLACEMENT
ACTUATOR DRIVING FORCE
JOINT DISPLACEMENT CONTROLLER
208
JOINT DISPLACEMENT COMMAND
202
ROBOT GEOMETRIC MODEL (KINEMATICS OPERATION PART)
204
CORRECTED DESIRED FOOT POSITION/POSTURE TRAJECTORY WITH DEFORMATION COMPENSATION
ACTUAL EACH FOOT FLOOR REACTION FORCE
COMPENSATION TOTAL FLOOR REACTION FORCE MOMENT ABOUT DESIRED ZMP Mdmd
COMPOSITE-COMPLIANCE OPERATION DETERMINER (INCLUDING COMPLIANCE CONTROL ON TOTAL FLOOR REACTION FORCE VERTICAL COMPONENT)
214
SELF POSITION/POSTURE ESTIMATOR
212
POSTURE STABILIZATION CONTROL CALCULATION UNIT
ESTIMATED BODY POSTURE
ESTIMATED LANDING POSITION/DIRECTION
206
DESIRED FLOOR REACTION FORCE DISTRIBUTOR
DESIRED EACH FOOT FLOOR REACTION FORCE CENTRAL POINT
DESIRED EACH FOOT FLOOR REACTION FORCE
200
GAIT GENERATOR
DESIRED ARM POSTURE
DESIRED BODY POSTURE
DESIRED BODY POSITION
DESIRED FOOT POSITION/POSTURE
DESIRED ZMP
DESIRED TOTAL FLOOR REACTION FORCE (INCLUDING COMPONENT IN VERTICAL DIRECTION)
DESIRED GAIT (DESIRED BODY POSTURE, ETC.)

FIG. 7

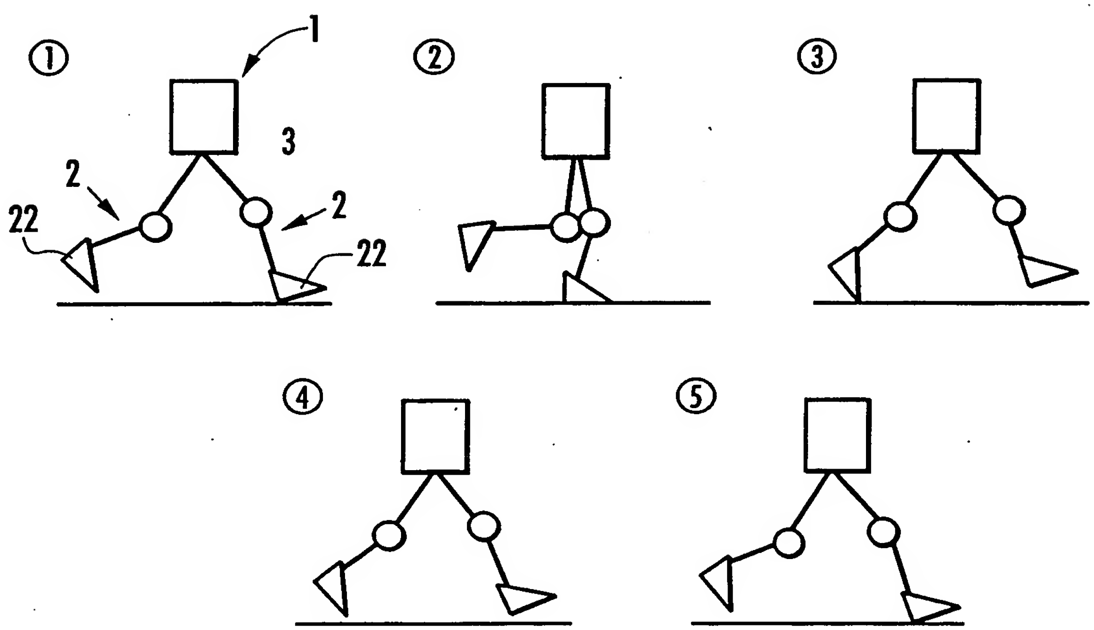

FIG.8 (a)

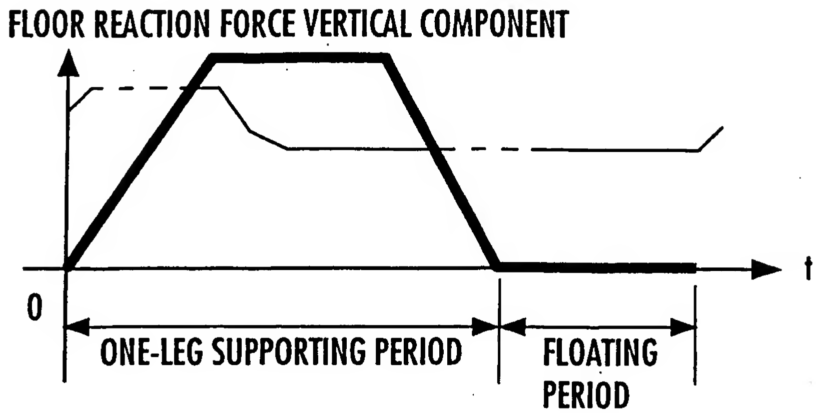

FIG.8 (b)

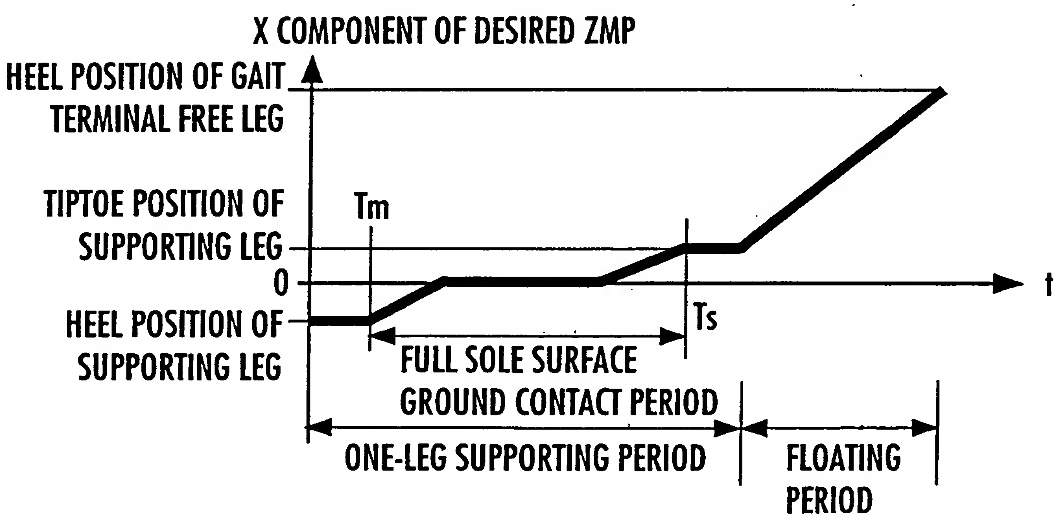

FIG.8 (c)

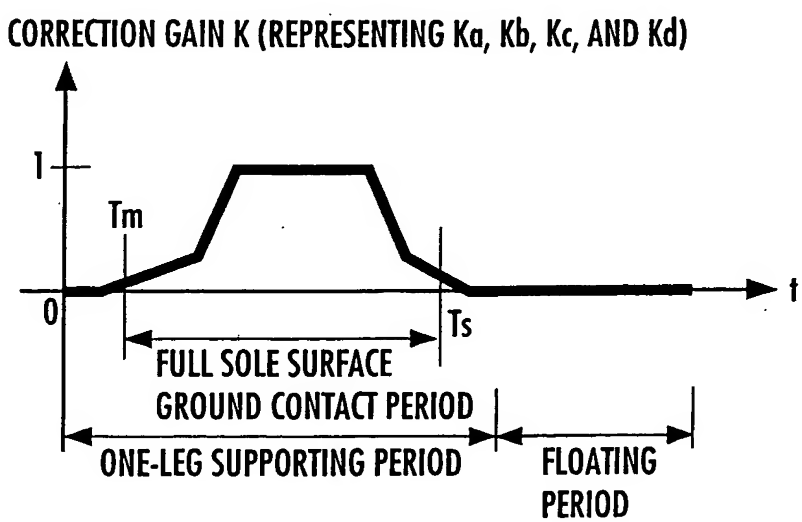

FIG. 9

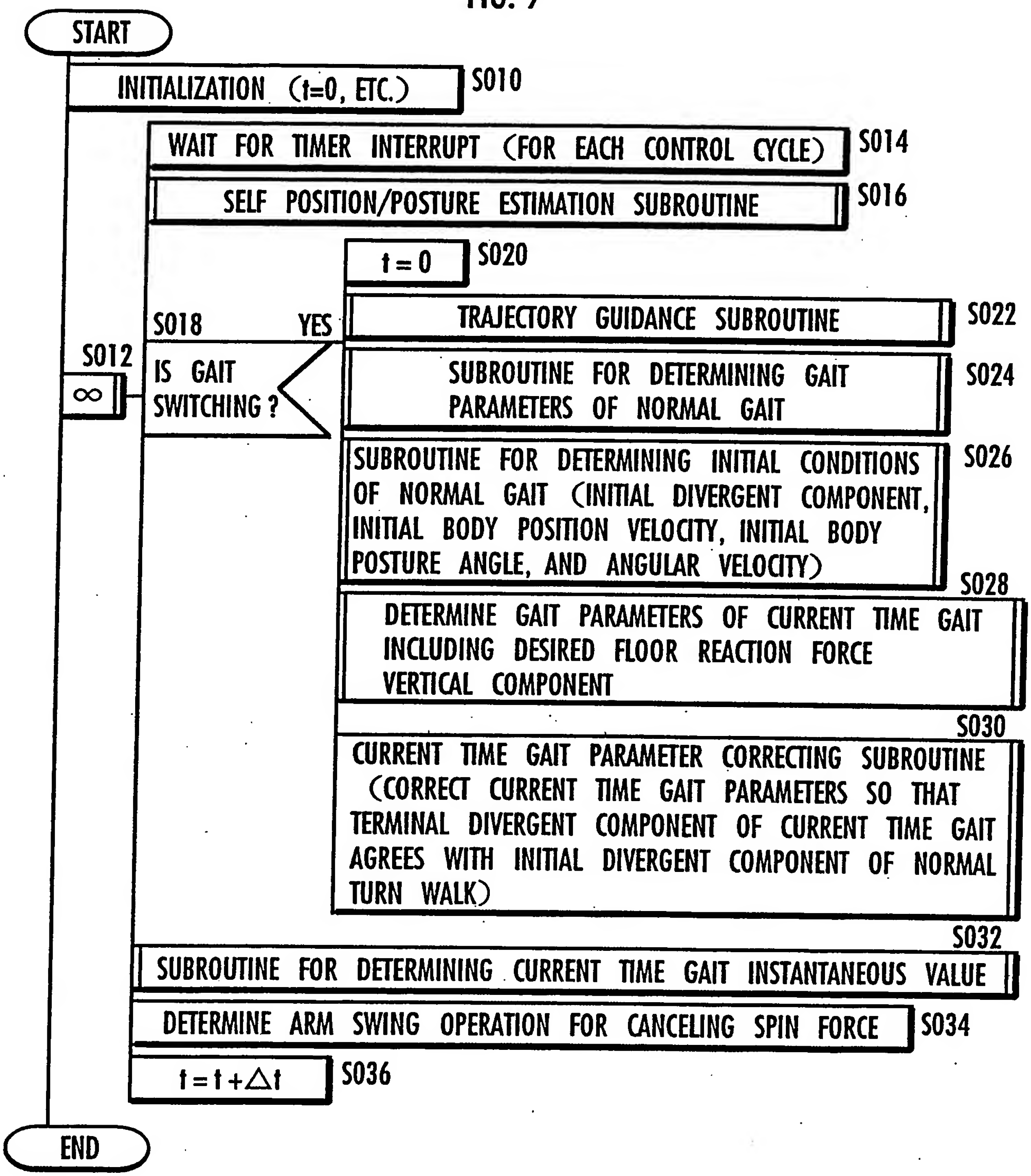
START
INITIALIZATION (t=0, ETC.)
S010
S012
∞
WAIT FOR TIMER INTERRUPT (FOR EACH CONTROL CYCLE)
S014
SELF POSITION/POSTURE ESTIMATION SUBROUTINE
S016
S018
IS GAIT SWITCHING ?
YES
t = 0
S020
TRAJECTORY GUIDANCE SUBROUTINE
S022
SUBROUTINE FOR DETERMINING GAIT PARAMETERS OF NORMAL GAIT
S024
SUBROUTINE FOR DETERMINING INITIAL CONDITIONS OF NORMAL GAIT (INITIAL DIVERGENT COMPONENT, INITIAL BODY POSITION VELOCITY, INITIAL BODY POSTURE ANGLE, AND ANGULAR VELOCITY)
S026
DETERMINE GAIT PARAMETERS OF CURRENT TIME GAIT INCLUDING DESIRED FLOOR REACTION FORCE VERTICAL COMPONENT
S028
CURRENT TIME GAIT PARAMETER CORRECTING SUBROUTINE (CORRECT CURRENT TIME GAIT PARAMETERS SO THAT TERMINAL DIVERGENT COMPONENT OF CURRENT TIME GAIT AGREES WITH INITIAL DIVERGENT COMPONENT OF NORMAL TURN WALK)
S030
SUBROUTINE FOR DETERMINING CURRENT TIME GAIT INSTANTANEOUS VALUE
S032
DETERMINE ARM SWING OPERATION FOR CANCELING SPIN FORCE
S034
t = t + Δt
S036
END

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FIG. 10

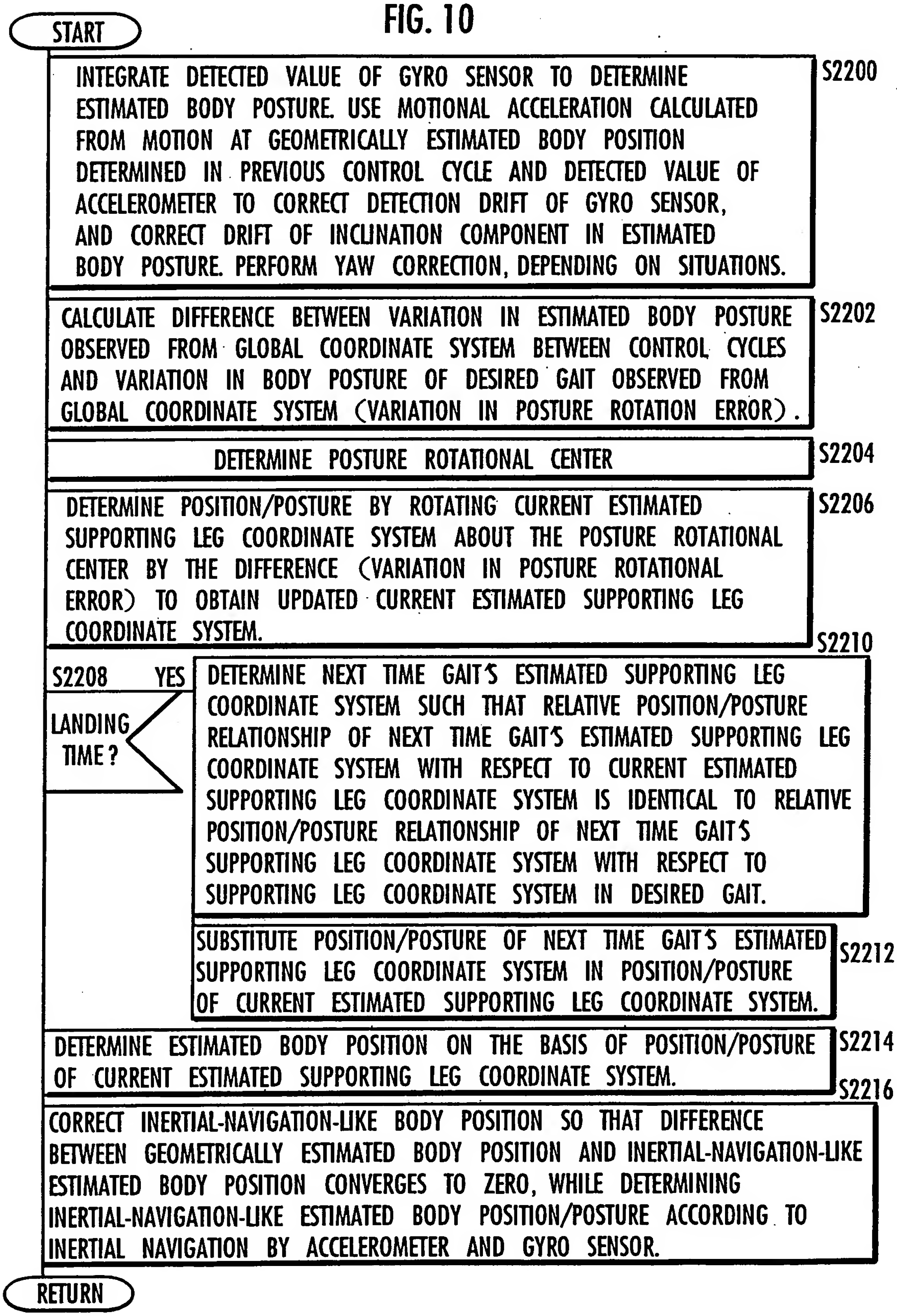


FIG. 11

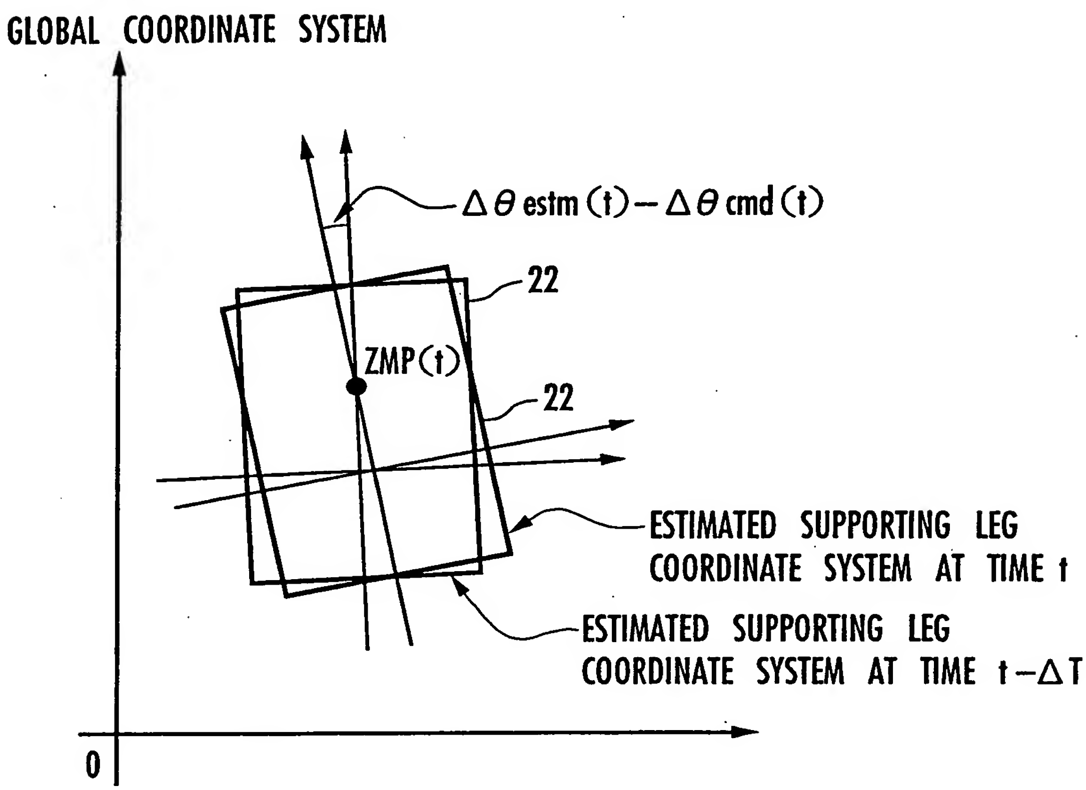

GLOBAL COORDINATE SYSTEM
Δθ estm (t) − Δθ cmd (t)
22
ZMP(t)
22
ESTIMATED SUPPORTING LEG COORDINATE SYSTEM AT TIME t
ESTIMATED SUPPORTING LEG COORDINATE SYSTEM AT TIME t−ΔT
0

FIG.12

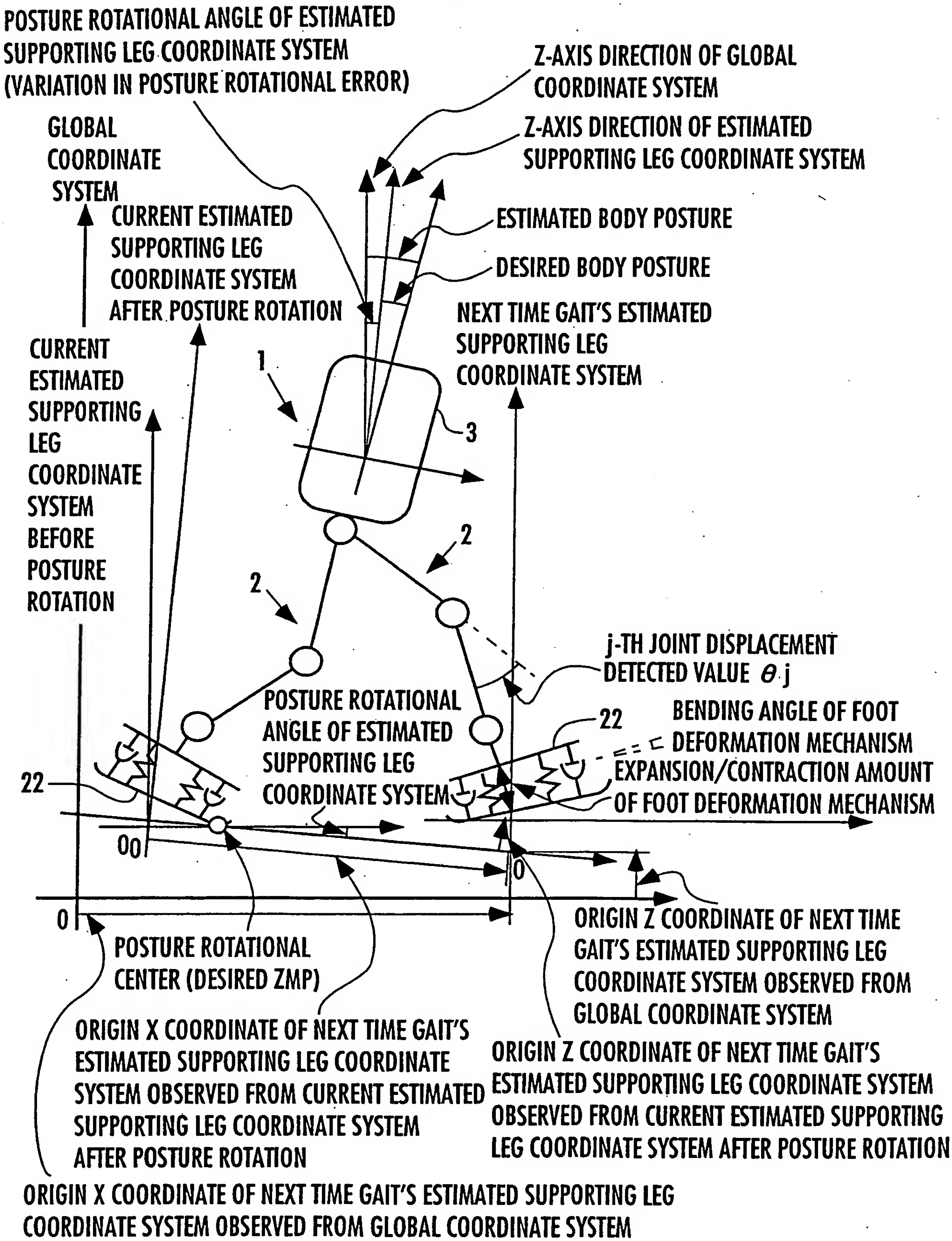
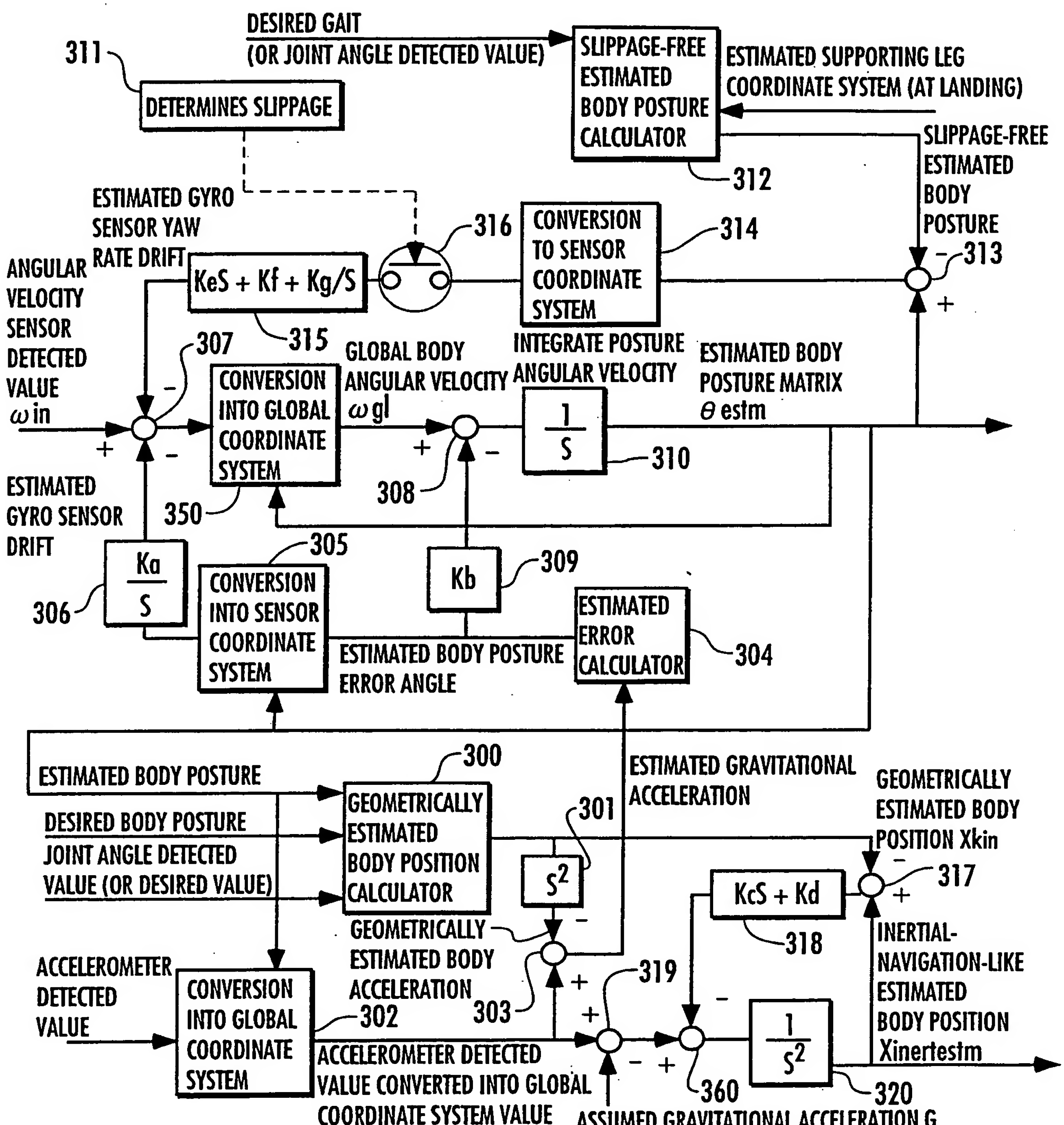

POSTURE ROTATIONAL ANGLE OF ESTIMATED SUPPORTING LEG COORDINATE SYSTEM (VARIATION IN POSTURE ROTATIONAL ERROR)
Z-AXIS DIRECTION OF GLOBAL COORDINATE SYSTEM
Z-AXIS DIRECTION OF ESTIMATED SUPPORTING LEG COORDINATE SYSTEM
GLOBAL COORDINATE SYSTEM
CURRENT ESTIMATED SUPPORTING LEG COORDINATE SYSTEM AFTER POSTURE ROTATION
ESTIMATED BODY POSTURE
DESIRED BODY POSTURE
NEXT TIME GAIT'S ESTIMATED SUPPORTING LEG COORDINATE SYSTEM
CURRENT ESTIMATED SUPPORTING LEG COORDINATE SYSTEM BEFORE POSTURE ROTATION
1
3
2
2
j-TH JOINT DISPLACEMENT DETECTED VALUE θj
POSTURE ROTATIONAL ANGLE OF ESTIMATED SUPPORTING LEG COORDINATE SYSTEM
22
BENDING ANGLE OF FOOT DEFORMATION MECHANISM
EXPANSION/CONTRACTION AMOUNT OF FOOT DEFORMATION MECHANISM
22
O0
O
O
ORIGIN Z COORDINATE OF NEXT TIME GAIT'S ESTIMATED SUPPORTING LEG COORDINATE SYSTEM OBSERVED FROM GLOBAL COORDINATE SYSTEM
POSTURE ROTATIONAL CENTER (DESIRED ZMP)
ORIGIN X COORDINATE OF NEXT TIME GAIT'S ESTIMATED SUPPORTING LEG COORDINATE SYSTEM OBSERVED FROM CURRENT ESTIMATED SUPPORTING LEG COORDINATE SYSTEM AFTER POSTURE ROTATION
ORIGIN Z COORDINATE OF NEXT TIME GAIT'S ESTIMATED SUPPORTING LEG COORDINATE SYSTEM OBSERVED FROM CURRENT ESTIMATED SUPPORTING LEG COORDINATE SYSTEM AFTER POSTURE ROTATION
ORIGIN X COORDINATE OF NEXT TIME GAIT'S ESTIMATED SUPPORTING LEG COORDINATE SYSTEM OBSERVED FROM GLOBAL COORDINATE SYSTEM

FIG.13



$$Ka=\begin{pmatrix} Kax & 0 & 0 \\ 0 & Kay & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad Kb=\begin{pmatrix} Kbx & 0 & 0 \\ 0 & Kby & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad G=\begin{pmatrix} 0 \\ 0 \\ g \end{pmatrix}$$

$$Kc=\begin{pmatrix} Kcx & 0 & 0 \\ 0 & Kcy & 0 \\ 0 & 0 & Kcz \end{pmatrix} \quad Kd=\begin{pmatrix} Kdx & 0 & 0 \\ 0 & Kdy & 0 \\ 0 & 0 & Kdz \end{pmatrix}$$

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FIG.14 (a)

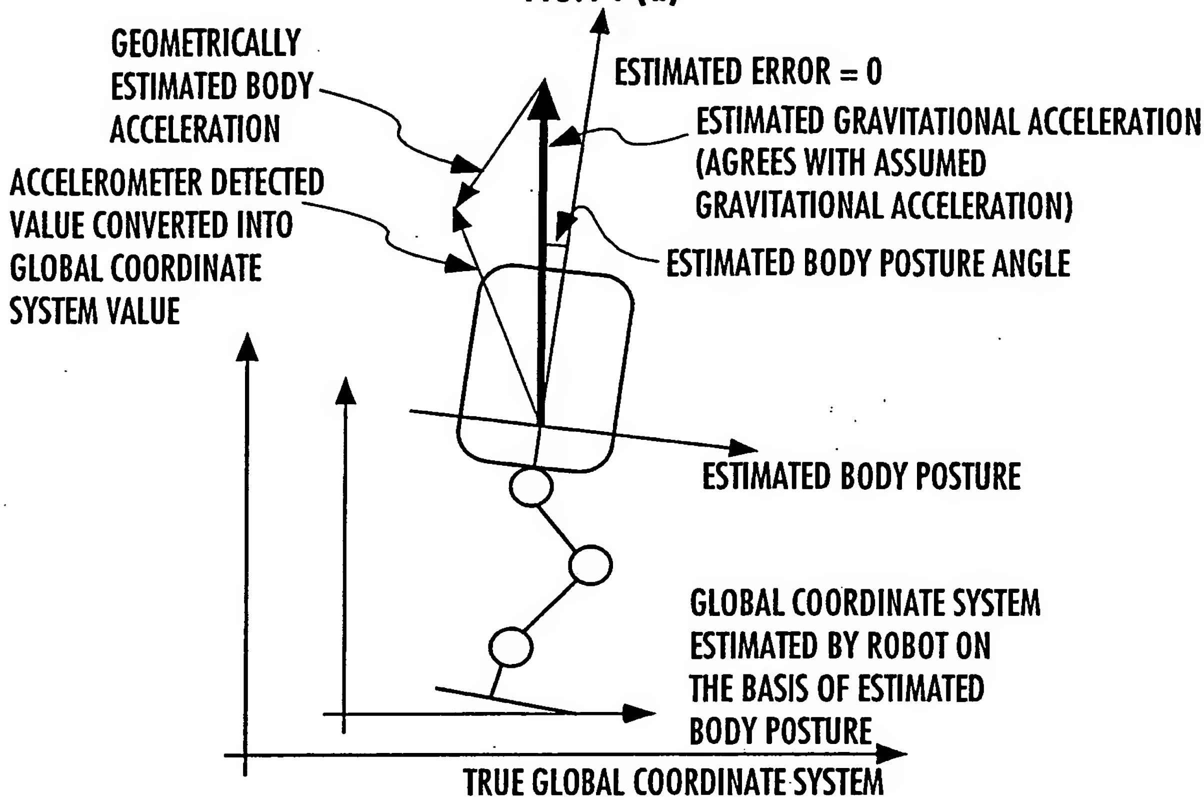


FIG.14 (b)

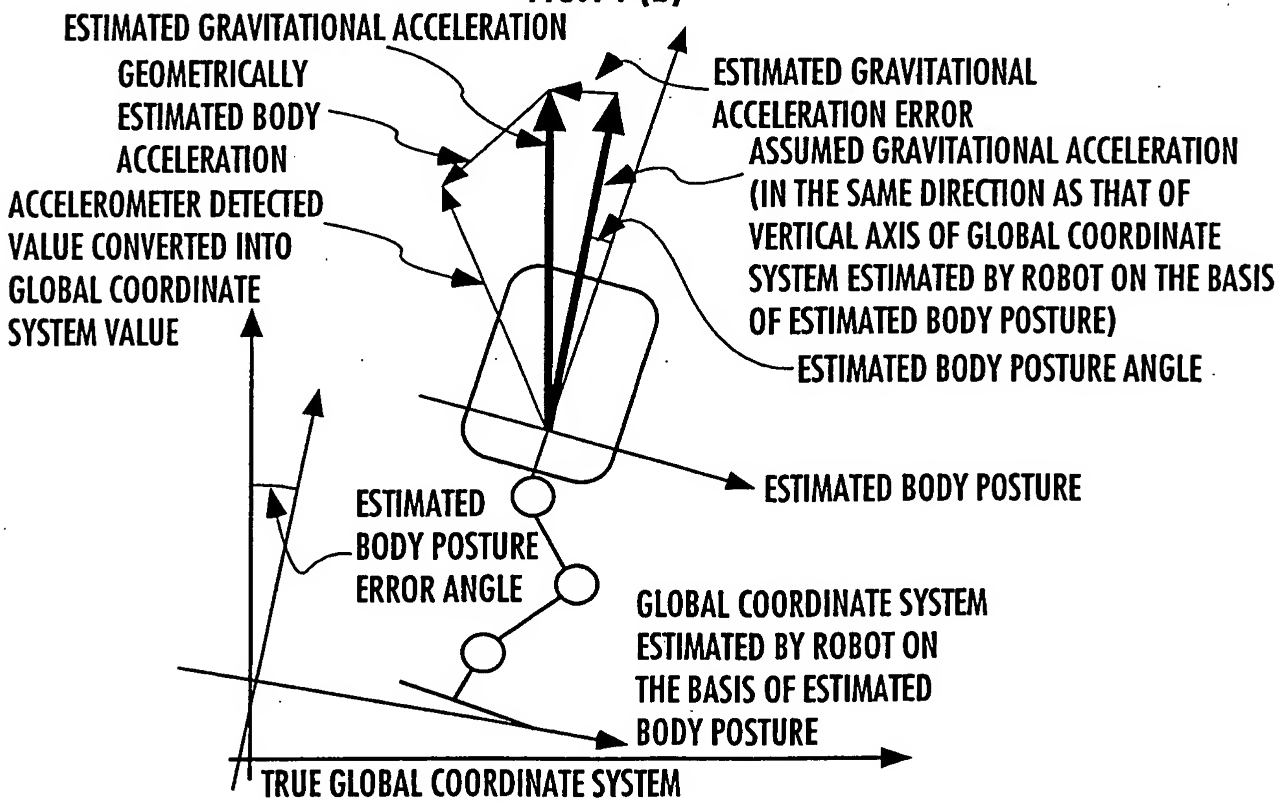
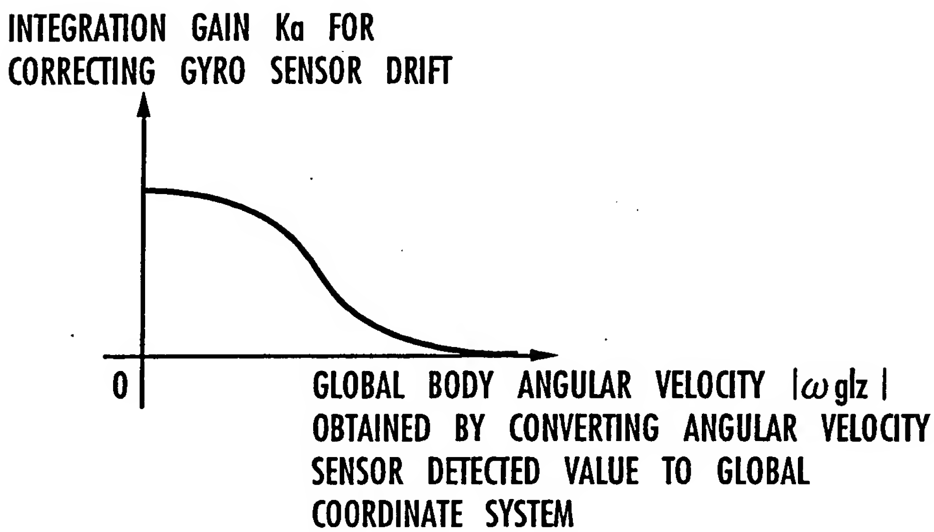


FIG. 15


INTEGRATION GAIN Ka FOR
CORRECTING GYRO SENSOR DRIFT
0
GLOBAL BODY ANGULAR VELOCITY |ωglz|
OBTAINED BY CONVERTING ANGULAR VELOCITY
SENSOR DETECTED VALUE TO GLOBAL
COORDINATE SYSTEM